Novel β-cyclodextrin Polymer Adsorbents for Removal of PFAS from Diverse Water Matrices

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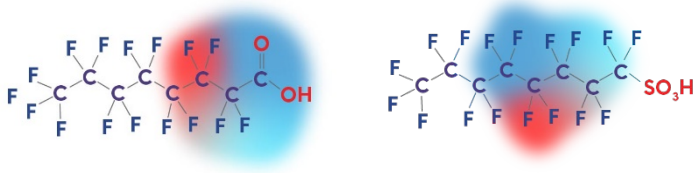
PFAS – Forever Chemicals in Water

- PFAS: Per- and polyfluorinated alkyl substances
- Widely-used: firefighting and household products
- Pervasive - GW, SW, WW, Leachate
- Persistent, Bio-accumulative, and Toxic

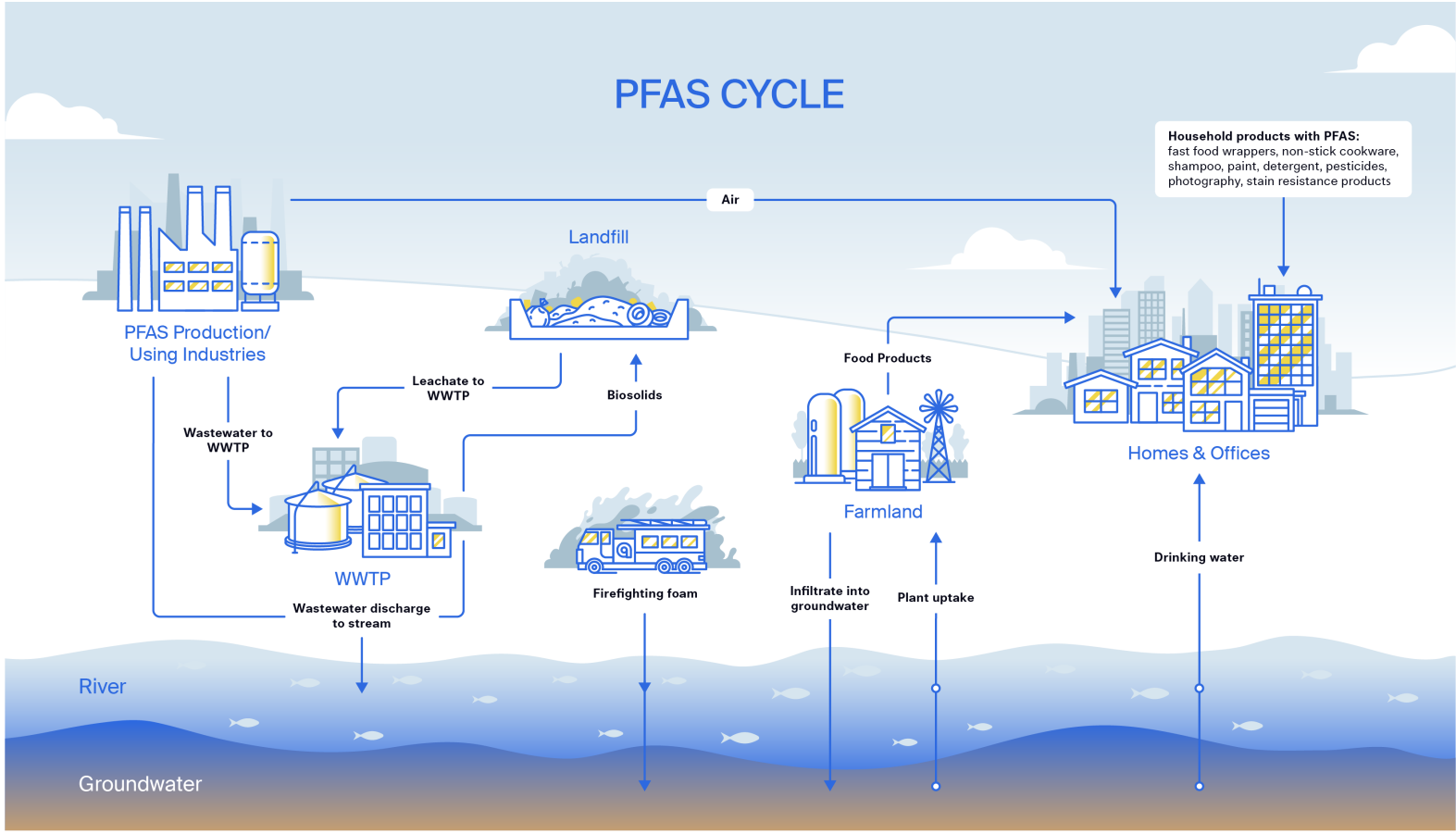


- Over 6,000 different PFAS structures

Challenges: PFAS are difficult to remove:
(1) diverse chemical structures;
(2) low concentrations (ng/L to µg/L);
(3) present in complex water matrices.

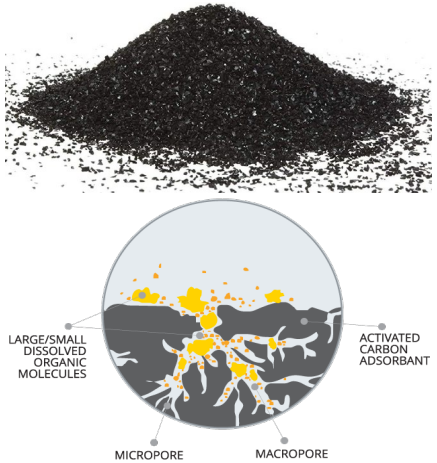
Point source and Nonpoint source Contamination:

PFAS's surfactant nature and high stability = Persistence



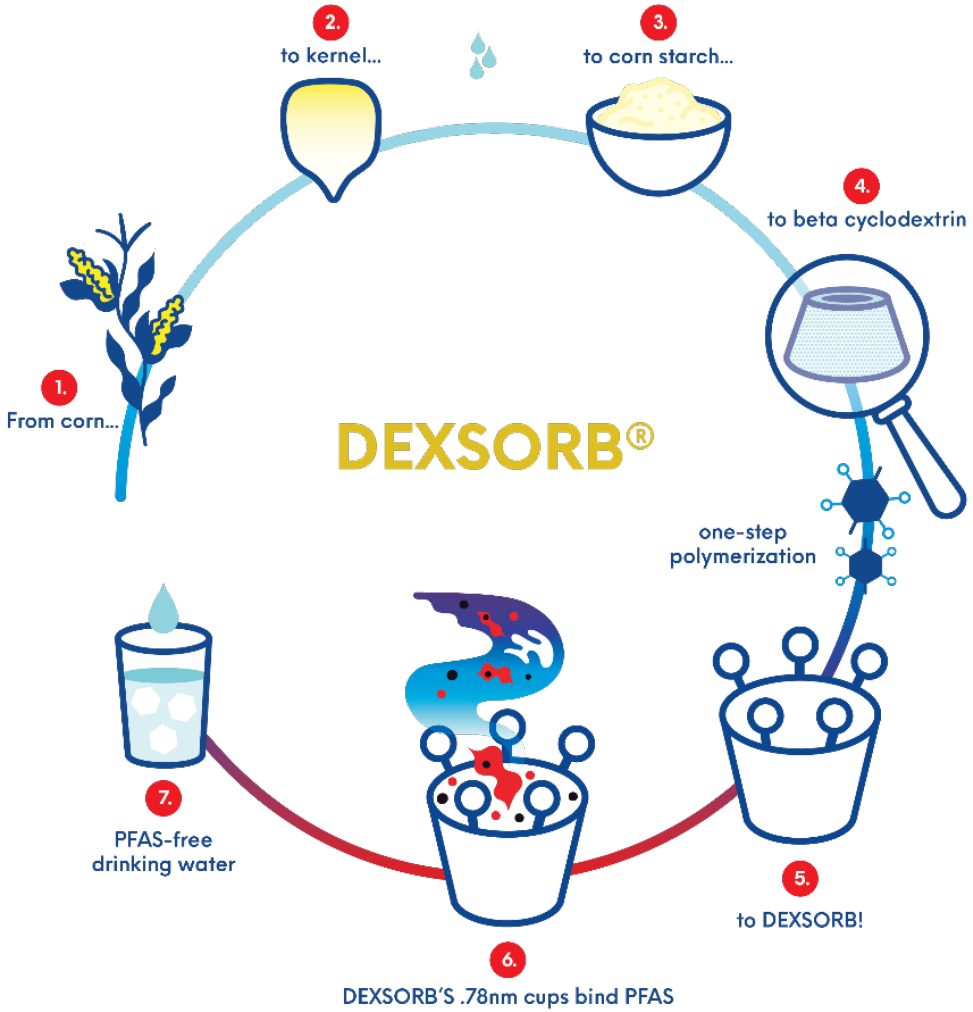
PFAS – Treatment Technology

Activated Carbon



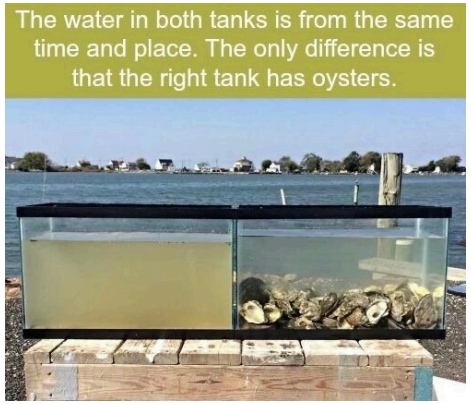
Ion Exchange Resin

Cyclodextrin Polymers



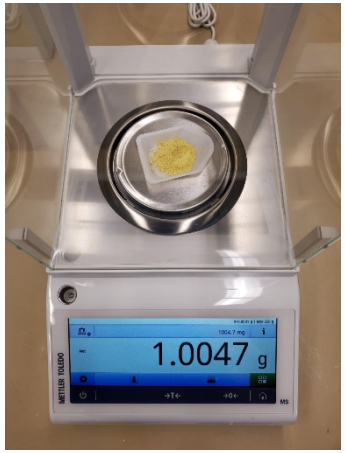
Reverse Osmosis

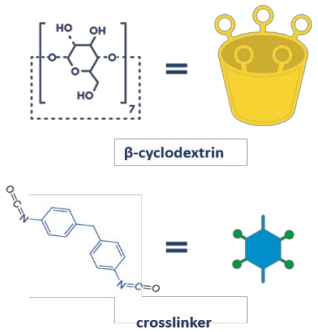
Shellfish Allergy

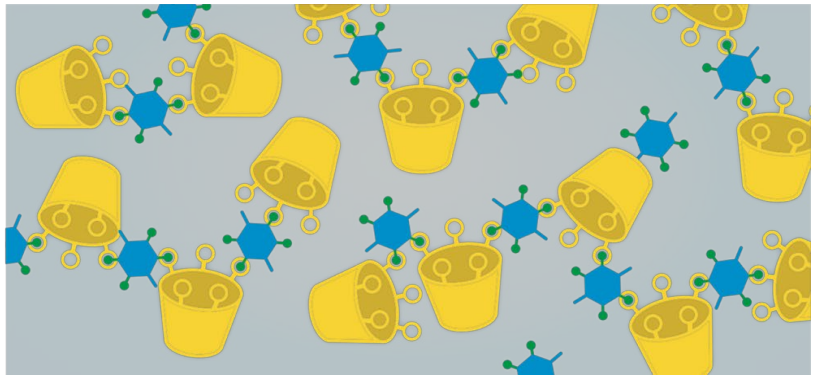


Proprietary Technology: DEXSORB®

One-Step Synthesis: 1 gram of DEXSORB = $3x10^{20}$ cyclodextrin cups







Features:

1. High Selectivity for micropollutants like PFAS.
2. Rapid Kinetics in both powder and granular forms.
3. High Capacity for micropollutant uptake.
4. Resistance to fouling of TOC and TDS (size exclusion).
5. Easy regeneration for multi-cycle reuse.

DEXSORB

micropollutants:
i.e. pharmaceuticals, pesticides

DEXSORB+

PFAS:
i.e. GenX, PFOA, PFOS

OFFICIAL LISTING

NSF certifies that the products appearing on this Listing conform to the requirements of NSF/ANSI/CAN 61 - Drinking Water System Components - Health Effects

This is the Official Listing recorded on February 3, 2021.

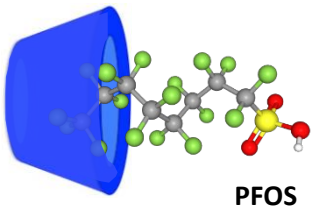
Facility: Skokie, IL

Trade Designation	Process Media Size	Water Contact Temp	Water Contact Material
Adsorption Media			
DEXSORB+ [1]	12 x 40 mesh	CLD 23	SYN

[1] This product is Certified for a maximum use level of 150 g/L.

Unique Feature: Size Exclusion & Size Inclusion

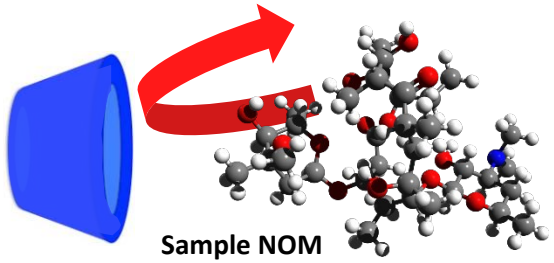
Host-Guest Complexation



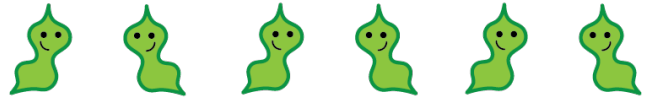
PFOS

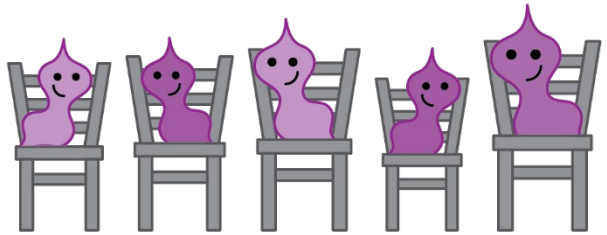
H
O
C
F
S
N

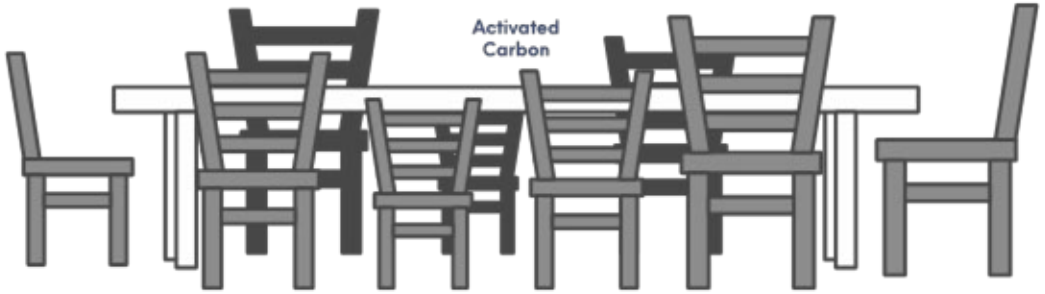
- Size inclusion for PFAS

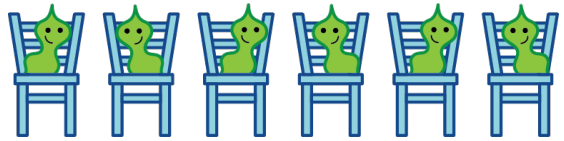


- Size exclusion for NOM, inorganic ions, etc.



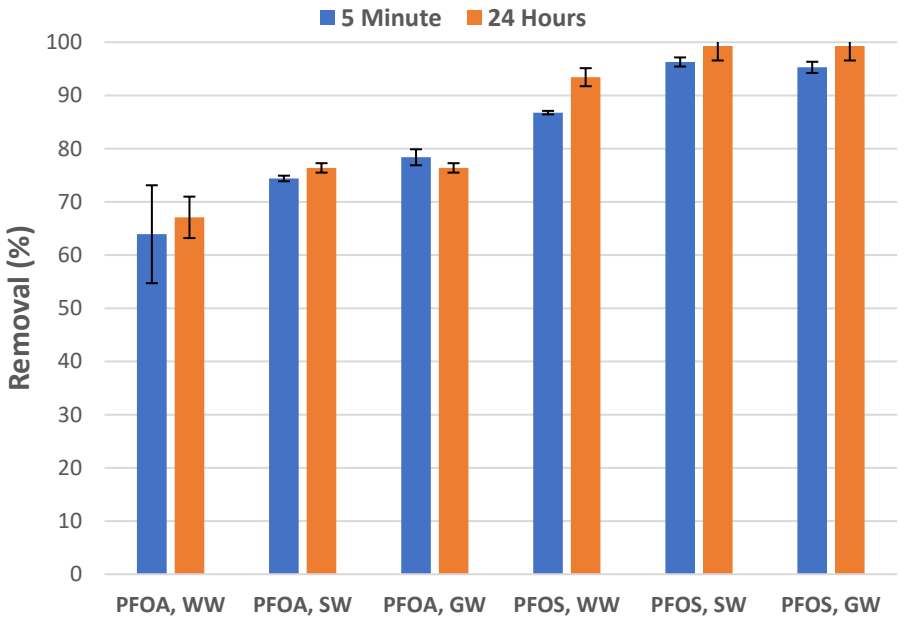




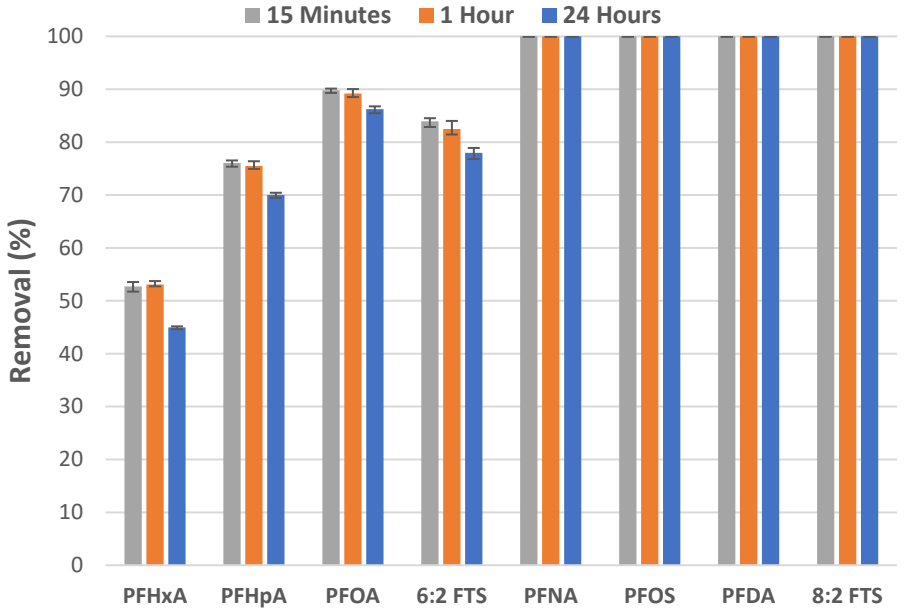


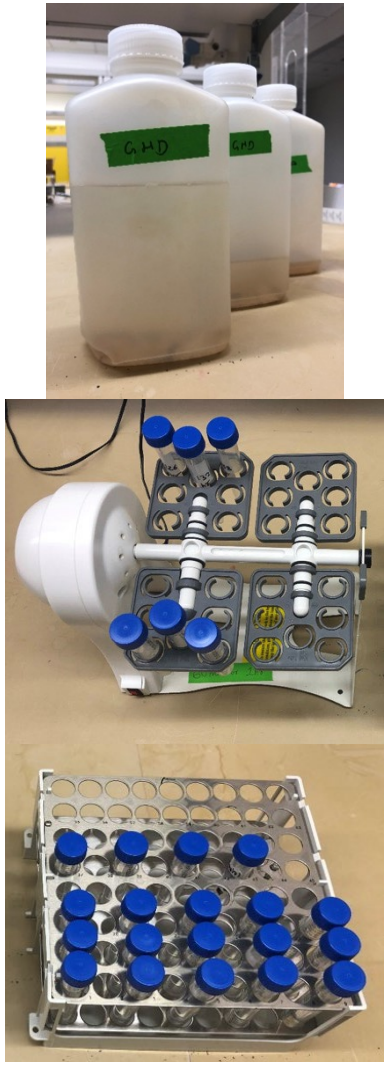
Performance: Consistent PFAS Removal in Complex Matrices

Removal in Different Matrices
DEXSORB+ Dose: 20 mg/L
DOM Concentration: 5.4 mg/L (WW); 2.5 mg/L (SW); <1 mg/L (GW)



Removal at High Contamination
DEXSORB+ Dose: 50 mg/L
Total PFAS level: 2650 ppt DOM Concentration: >5 mg/L





Resistant to Matrix Effects:

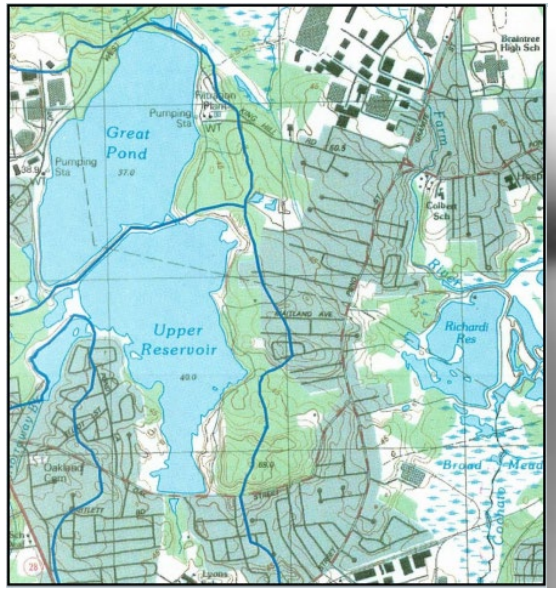
- **Consistent performance across different water quality conditions (e.g., DOM)**
- **Allows application in diverse water matrices**

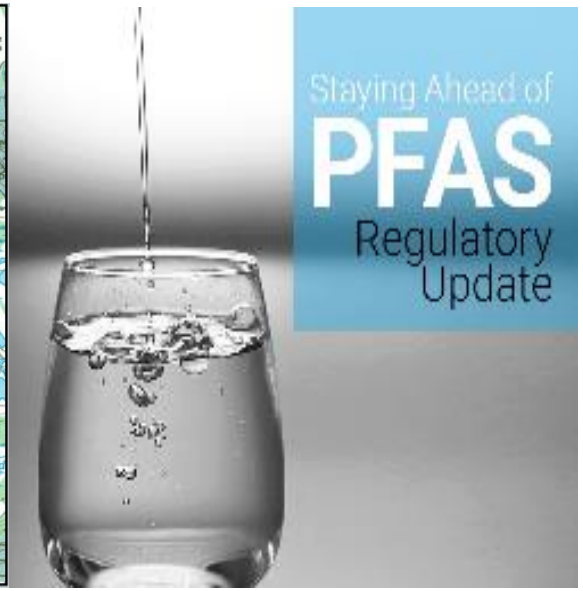
Efficiency at High PFAS Contamination:

- **Rapid and efficient removal across different PFAS chain lengths and contamination levels**

Drinking water PBF treatment at Town X, MA

Town X, MA



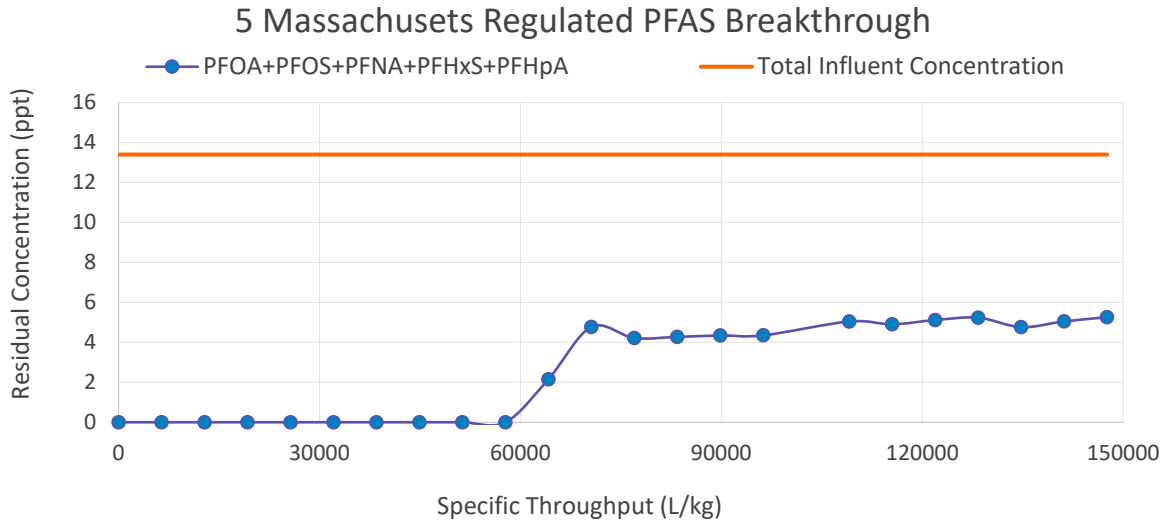


RSSCT Conditions:

- **Run for 10 days**
- **Simulated EBCT: 5 min**
- **Throughput: 5 gallons**
- **Loading: 0.08 g.**

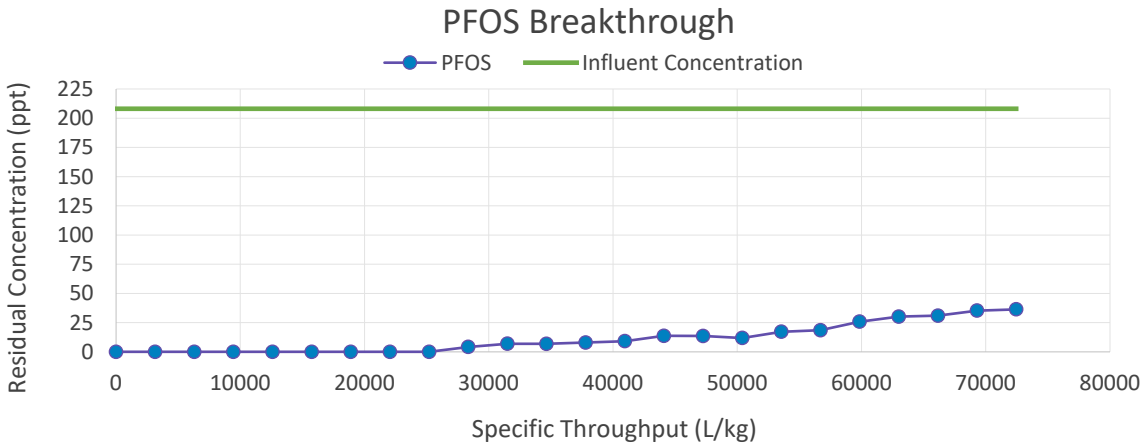
Performance:

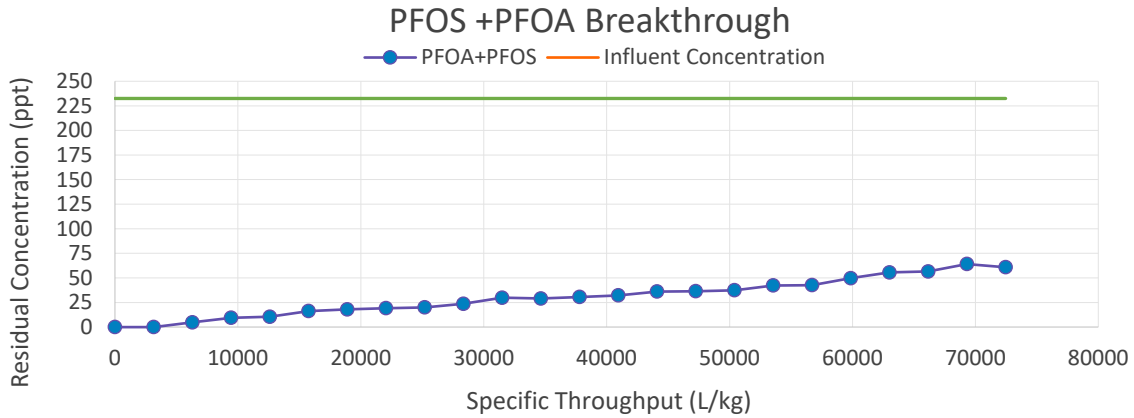
- **1 kg for the treatment of more than 150,000 L;**
- **Equally effective against short- & long-chain PFAS**



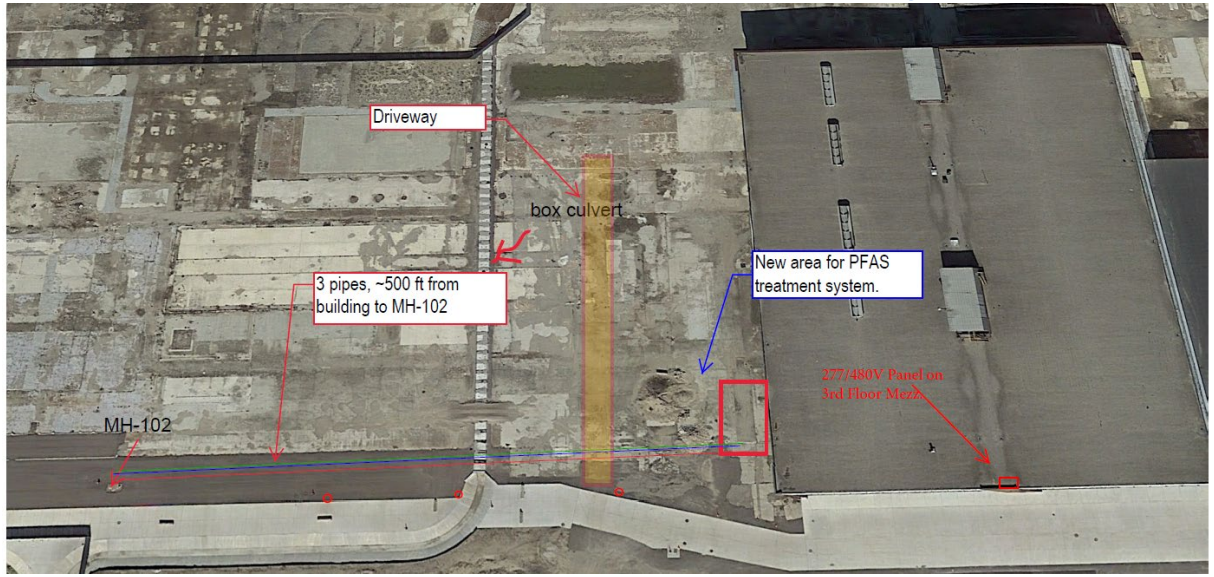
Industrial Groundwater Remediation in Michigan

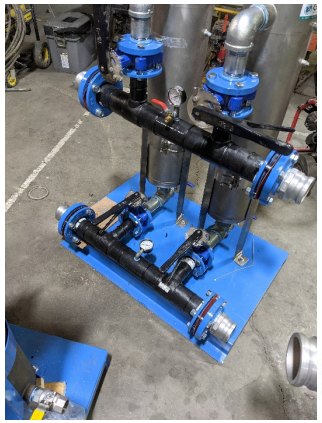
RSSCT results, superior PFAS removal:

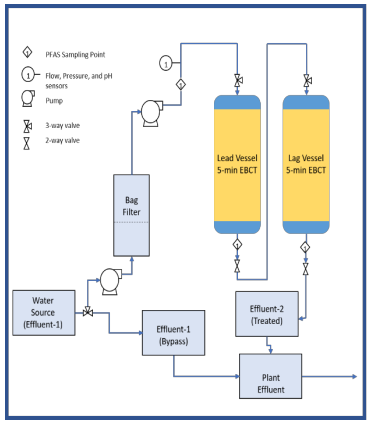


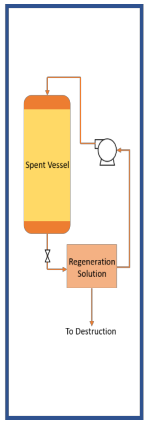


On-site pilot test, CP compact vessel system:

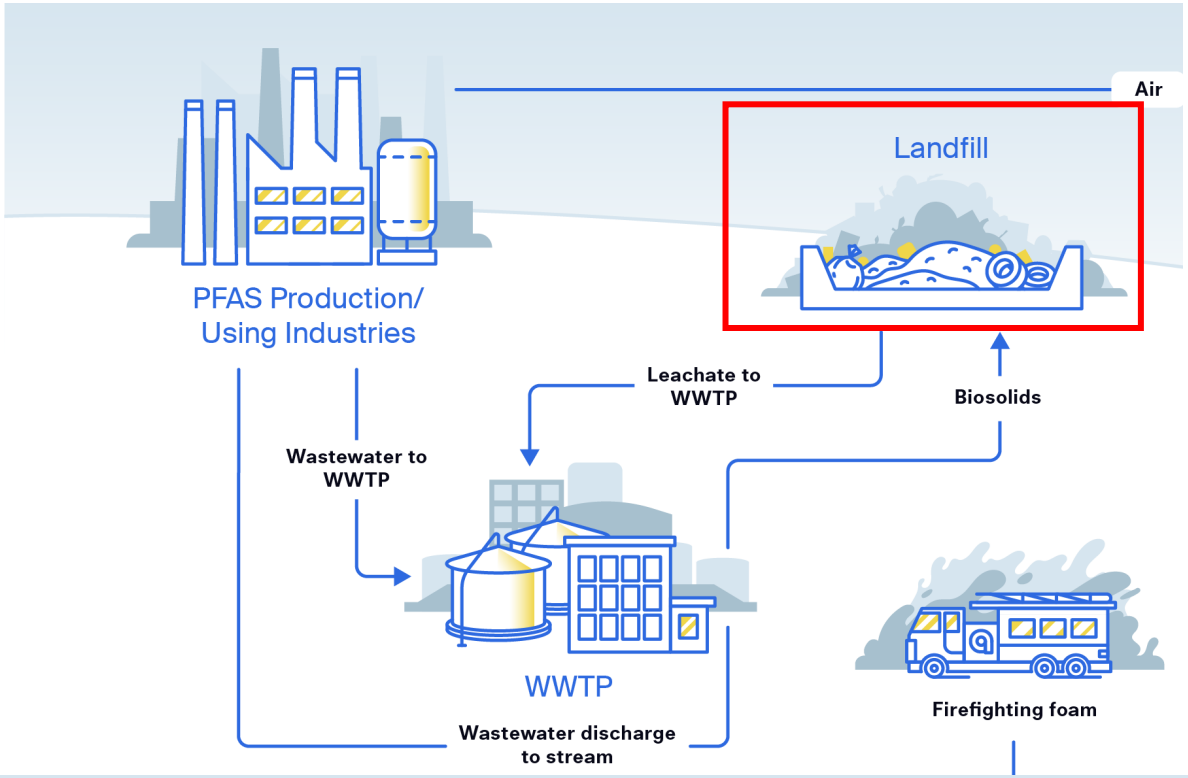








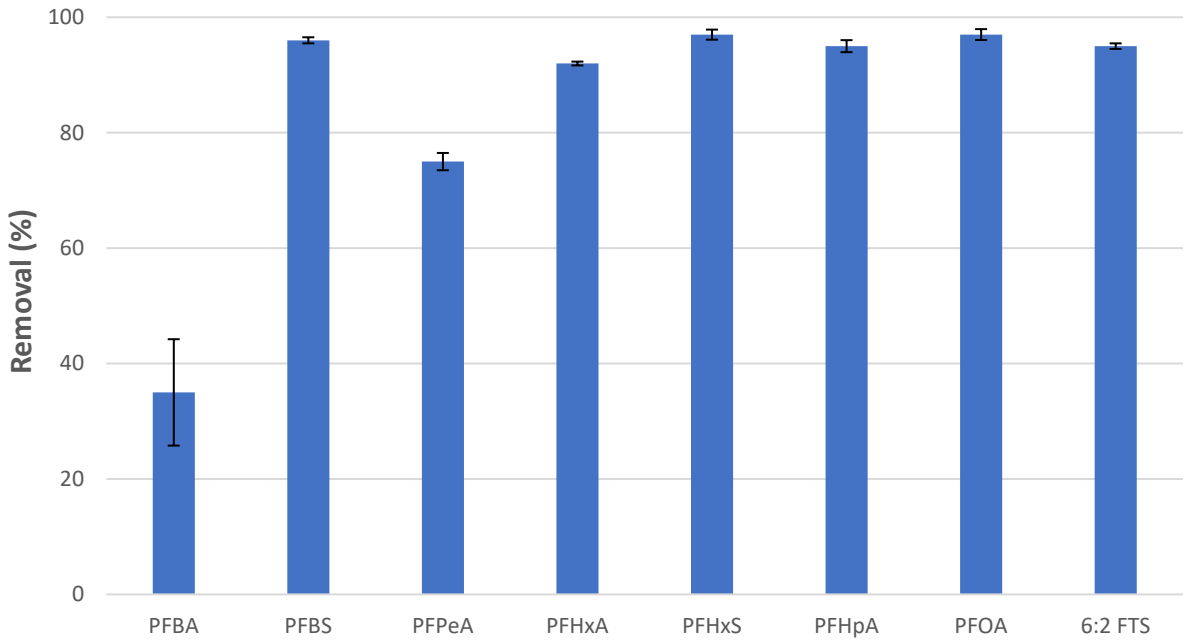
Landfill Leachate Pre-treatment in New York



Third-party leachate treatment study:

DEXSORB+ Dose: 5 g/L; Contact time: 30 minutes

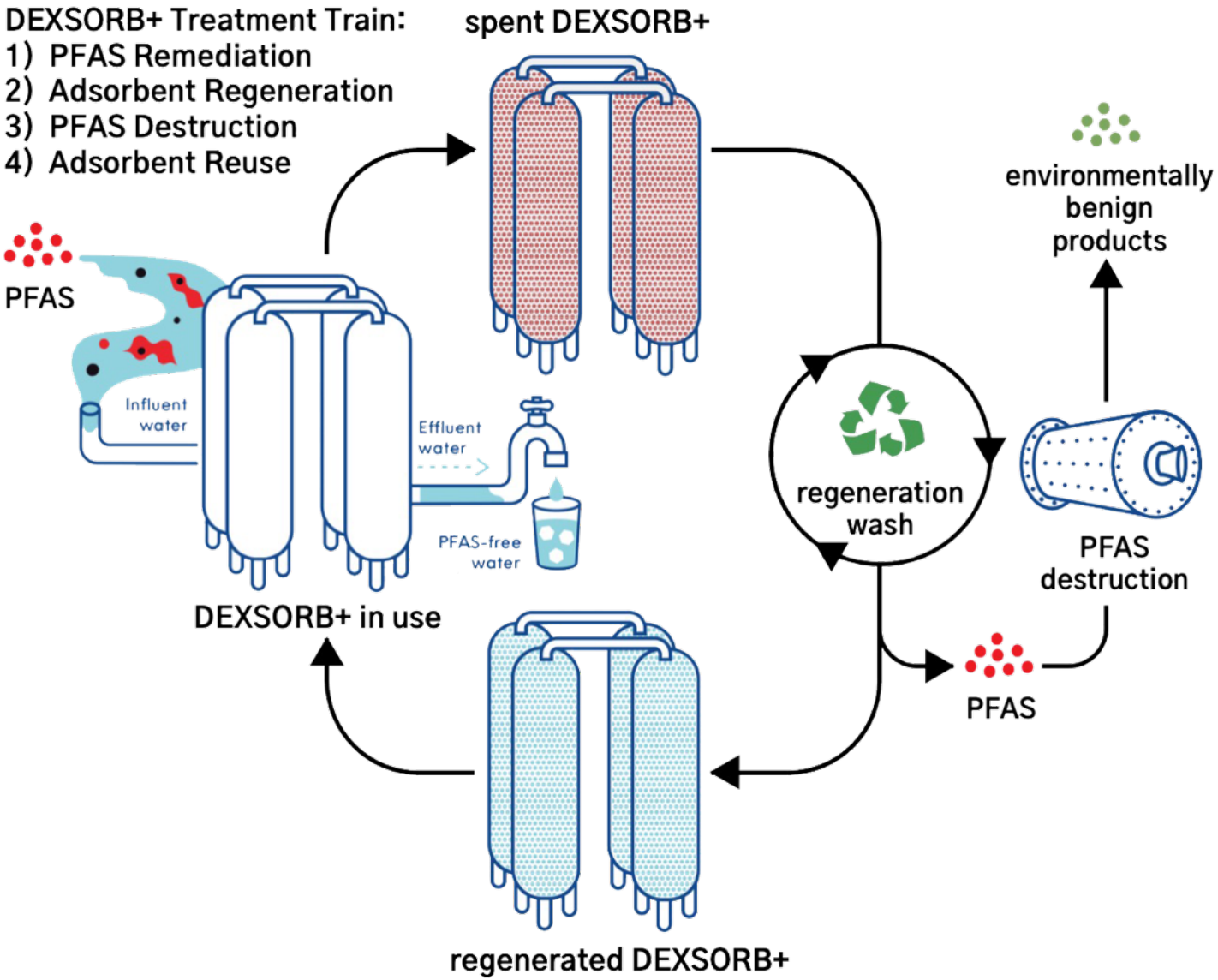
TOC: > 1000 mg/L; TDS: : > 5000 mg/L



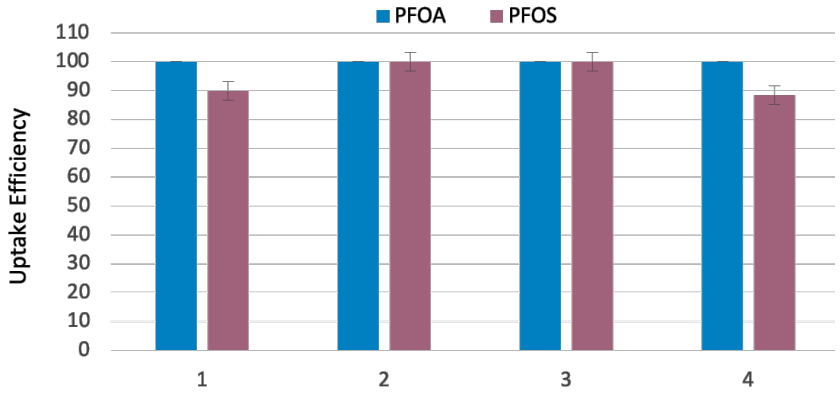
Important Observations:

- **Rapid kinetics and high capacity are maintained in the most challenging matrix**
- **Both short- and long-chain can be effectively removed**

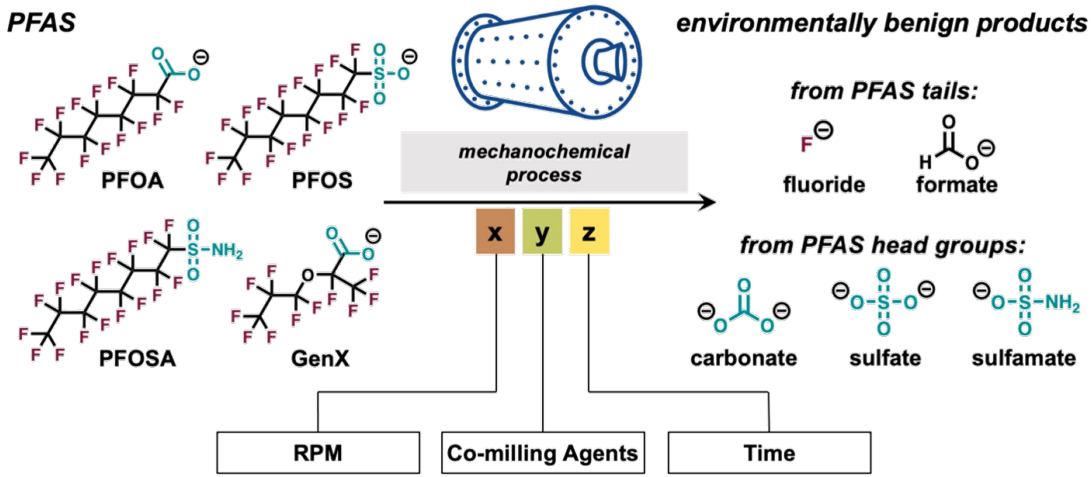
DEXSORB®: From Separation to Mineralization for PFAS



Multi-cycle regeneration for Reuse



EPA funded Proprietary Process

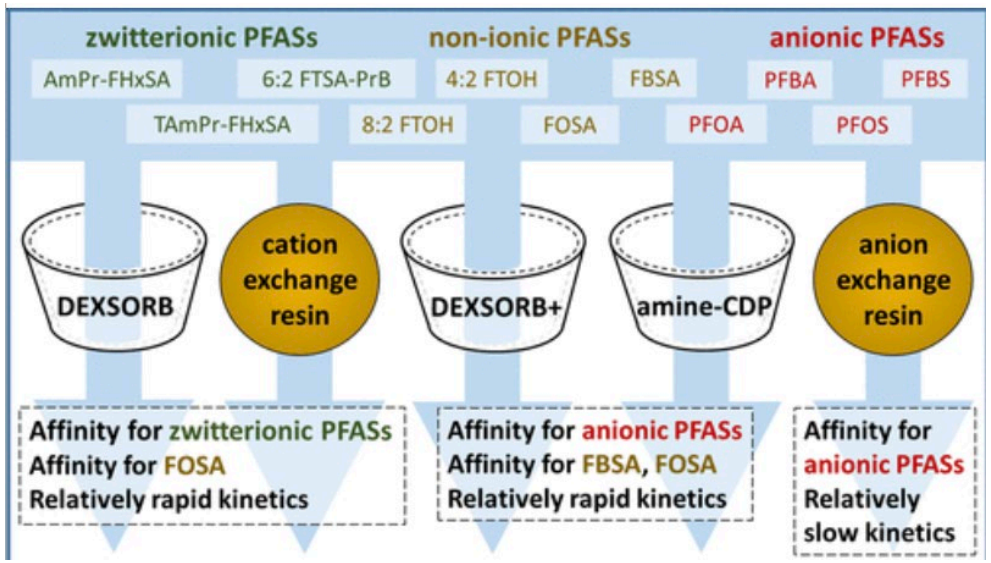


DEXSORB®: Effective Uptake of Emerging PFAS

ES&T – 9.14.2020

"β-Cyclodextrin Polymers with Different Cross–Linkers and Ion– Exchange Resins Exhibit Variable Adsorption of Anionic, Zwitterionic, and Nonionic PFASs." Environ. Sci. Technol. 2020, 54, 19, 12693–12702.

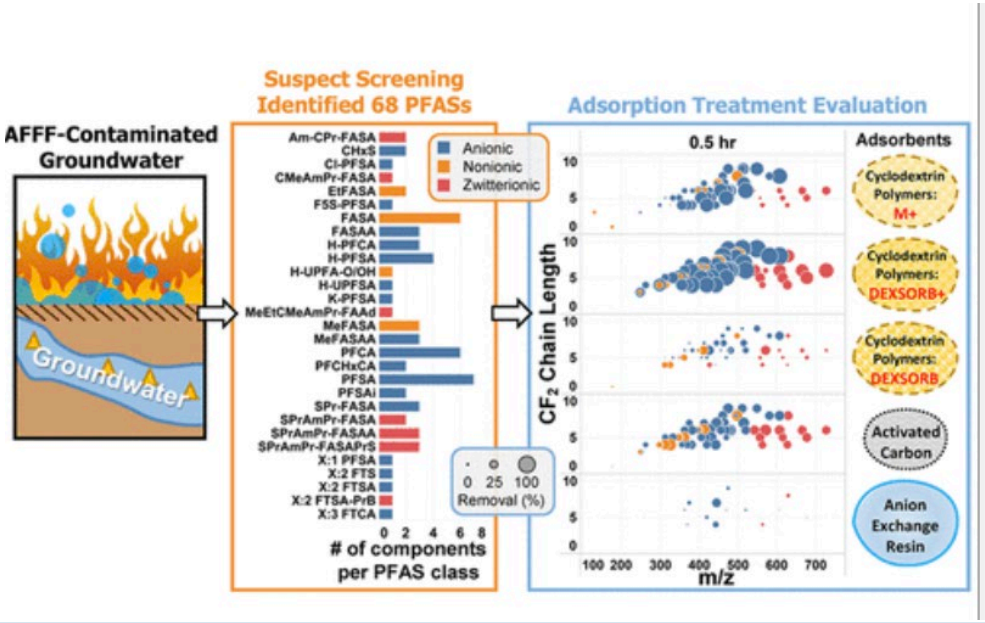
DEXSORB® exhibits efficient removal of zwitterionic, anionic, and non-ionic PFAS.



ES&T Letters – 10.15.2020

"Evaluating the Removal of Per– and Polyfluoroalkyl Substances from Contaminated Groundwater with Different Adsorbents Using a Suspect Screening Approach." Environ. Sci. Technol. 2020, DOI: 10.1021/acs.estlett.0c00736.

DEXSORB® show broad efficacy against all 68 identified PFAS in short contact time.



Thanks for your attention!

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